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Research Paper

Effect of an Indian Percussion Music Instrument on the Oral Health, Motor Skills, and Social Skills of Children with Autism

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ABSTRACT

Background: Children with Autism Spectrum Disorder (ASD) are characterized by deficit in social skills. Motor skill impairments and poor oral health are consistent with these individuals. An intervention targeting an improvement in multiple deficits of ASD needs to be developed. This study aimed to improve the oral health status, motor skills and social skills of children with autism by means of a music therapy involving self-playing a percussion music instrument. Methods: This study employed a randomized controlled trial design where children with autism between 4-12 years of age were divided into a control (n=12) and an experimental (n=12) group. The control group received only oral hygiene instructions whereas the experimental group received a music therapy intervention along with the oral hygiene instructions. Standardized scales were used for measuring the oral health status, motor skills and social skills. Descriptive independent t-test was done for intergroup comparison and paired t-test was done for intragroup comparison. Results: There was a significant change in the plaque index, motor skills, social participation and social reciprocation of the participants in the experimental group. Conclusion: This study showed that music therapy for children with autism through playing the Tabla shows potential for improving their oral health, motor skills and social skills.

Keywords: *Autism, Tabla, Oral Health, Motor Skills, Music Therapy, Social Skills*

Autism Spectrum Disorder (ASD) is a pervasive neurodevelopmental disorder characterized by impairments in social communication and restricted, repetitive patterns of behavior, interests or activities (DSM-V, 2013). Even though not a part of its diagnostic criteria, motor skill impairments can be commonly seen in children with ASD.

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These motor skills, when combined with cognitive dysfunction, can hinder sequential activities (Mari et al., 2003).

Social skills are directly related to cognitive functioning and help in routine activities like health care, grooming, eating, etc. The shortcomings in performing these tasks can be seen in individuals with ASD. They exhibit stereotypical behaviors linked to the upper limbs and body balance (Jasmin et al., 2009; Jeste, 2011). One social behavior commonly exhibited by autistic individuals is tactile defensiveness which is "a hypersensitivity or hyperresponsivity to touch situations that most persons find non-threatening." Patients exhibiting tactile defensiveness often display an avoidance-withdrawal response when confronted with a certain tactile stimulus. Aversion to dental care is a commonly seen behavior in tactile defensiveness. Since dental care is considered a self-care skill, this trait is categorized under "Level 2/Moderate" severity of sensory defensiveness syndrome (Baranek et al., 1997; Stagnitti et al., 1999). Thus, children with autism exhibit poor oral health status (da Silva et al., 2017; du RY et al., 2019).

Apart from social skills, the deprived oral health in autistic individuals can be attributed to their motor skill comorbidities. Impaired finger-thumb opposition, clumsiness, and lack of visuomotor coordination are commonly reported behaviors in autism (Mari et al., 2003; Jasmin et al., 2009). Furthermore, motor components are directly related to broader aspects of development, including language, social interaction, and learning (Jeste 2011). Toothbrushing requires the involvement of multiple muscles of the upper limb with better cognitive ability (Uenoyama & Inada, 1990). Hence, poor upper limb motor coordination is one of the reasons for poor oral hygiene in children with autism (Luppanapornlarp et al., 2010).

There have been multiple attempts previously to teach autistic individuals the daily routine of toothbrushing. These include dividing the action of toothbrushing into various steps as a learning pattern, visual pedagogy, video modeling, and Picture Exchange Communication System. However, each of these teaching methodologies was either time-consuming, did not guarantee any improvements in oral health, or was difficult for the caretakers to accept (Smith and Belcher, 1985; Matson et al., 1990; Pilebro and Backman, 2005; Popple et al., 2016; Al-Batayneh et al., 2019). Thus, we are inclined to approach a new intervention system that helps improve the oral health status of children with autism such that the mode of teaching is interesting and engaging for the caretakers.

Music provides a multimodal stimulus that can activate the brain's visual, somatosensory, auditory, and motor components (Wan et al., 2010). The World Federation of Music Therapy defines music therapy as "the professional use of music and its elements as an intervention in medical, educational, and everyday environments with individuals, groups, families, or communities who seek to optimize their quality of life and improve their physical, social, communicative, emotional, intellectual, and spiritual health and wellbeing. Research, practice, education, and clinical training in music therapy is based on professional standards according to cultural, social, and political contexts" (WFMT, 2020).

Music therapy through interactive or self-instrument playing significantly improves cognitive, communication, behavioral, musical, and motor skills in individuals with autism (Kaplan and Steele, 2005).

Musical characteristics in children with autism were first described in 1953 (Sherwin, 1953). The key points were:

- An unusual interest in music
- A tendency to sing differently from an average child
- An oftentimes unusual ability to reproduce familiar pieces with extraordinary accuracy

Music therapy has been used as an intervention for autism since the 1940s. The earliest studies done on children who fell in the autism spectrum that involved playing percussion instruments by the subjects were reported by Goldstein C. and Thaut M. Furthermore, the studies that link social skills and autism were carried out by Paul Nordoff and Clive Robbins in the early and mid-1960s (Reschke-Hernandez, 2011).

An Indian Percussion Music instrument called Tabla consists of a pair of drums. Sound is produced by hitting the Tabla on its leather-covered surface with precision and power of the fingers and palm, in coordination with the wrist, elbow, and shoulder. Hence, the entire arm is used to produce the desired sound from the instrument.

Music-making is one medium that engages the mirror neuron system (MNS). This is responsible for goal-directed, sequential, and skilled movements (Wan et al., 2010). The hand is given a major portion of neural apparatus (somatosensory and motor cortical areas) (Mari et al., 2003). Thus, playing an instrument like Tabla that utilizes the entirety of the upper limbs can have multiple effects. One of these effects includes training those hand muscles used in playing the Tabla and brushing the teeth.

Rhythmic cueing through an electronic metronome or a prepared form of music has been shown to improve muscular control, time-based movements, and proprioceptive control mechanisms (Sarkamo et al., 2013; El-Shemy and El-Sayed, 2018). In this study, an electronic metronome (Sunadamala Dx 2009, Radel Electronics Pvt. Ltd.) delivered rhythmic auditory cueing.

Considering the lack of evidence available among children with ASD, the present study was planned to evaluate the changes in oral health status, motor skills, and social skills by training them to play a percussion instrument (Tabla) (Figure 1).

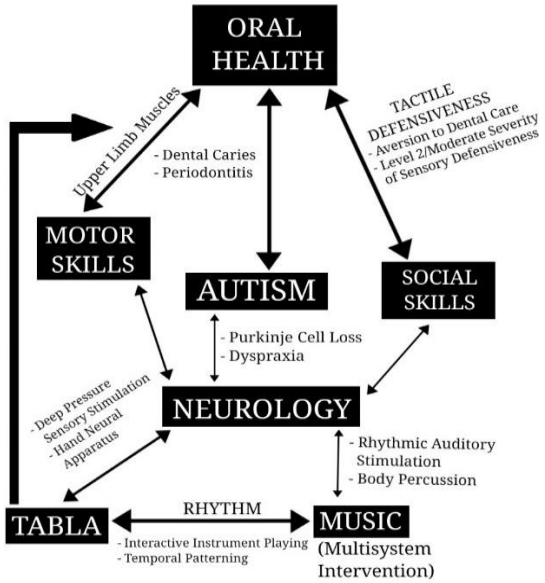


Figure 1 Linking Autism, Oral Health and Music

MATERIALS AND METHODS

Objective

The present study evaluated the effect of a music therapy intervention on the oral health status, motor skills, and social skills of children with autism. A randomized controlled trial design was opted for. A simple randomization technique divided the participants into a control and an experimental group. The allocation of the participants to either group was blinded to the researchers. This manuscript is reported using the CONSORT guidelines.

Inclusion criteria

Participants chosen for the study were required to have a confirmed diagnosis of ASD as per the Childhood Autism Rating Scale (CARS). A pediatric neurologist and a psychologist confirmed this diagnosis. All included participants should be in the age range of 4-12 years. Children with autism were included only if they had signed written consent from their caretaker or parent addressing their participation in the study.

Exclusion criteria

Children with impaired vision, and hearing, or having a congenital absence of limbs were excluded from the study. Participants in music, drawing, creative drama training sessions, etc. during the intervention period were excluded from the study. Participants were not included in the study if they received another music therapy intervention within six months before the start of the training duration. A participant is excluded from the study if he or she skipped a music therapy session.

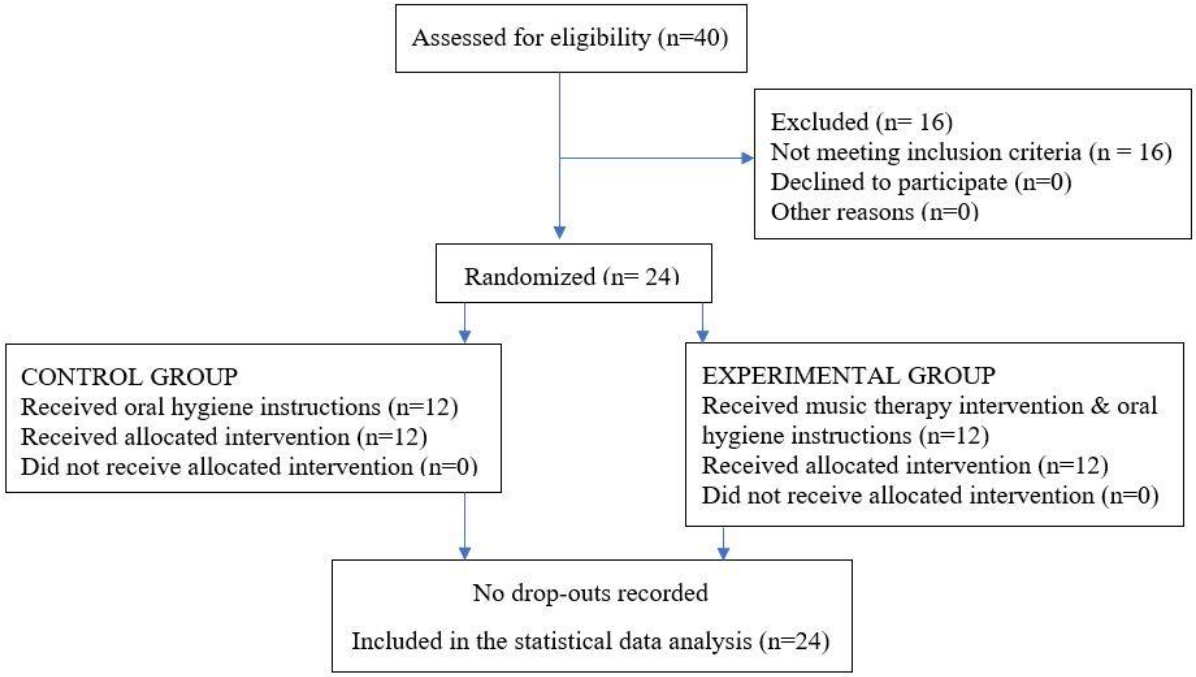
Sample size calculation

- ***Sample size*** calculation was done using the beta-power method. An effect size of 0.97 was considered given the mean and standard deviation values considered. A two-tailed input at a power size of 85% revealed the total sample size to be 22 – 11 in each group.
- ***Enrollment:*** 40 children from two special kids' schools in Ahmedabad, India were initially screened. 24 participants who met the inclusion criteria were enrolled in the study. Of the 24 participants chosen, 19 were boys and 5 were girls.
- ***Randomization:*** A simple randomization technique utilizing a computer-generated lottery method was used to allocate the participants into an experimental and control group of equal sample size (n=12 for each group).
- ***Allocation concealment:*** Only one of the researchers (VB) was aware of the allocation of participants in either group.
- ***Blinding:*** Researchers who carried out the pre-post-intervention evaluations (JM, MK) and the one who carried out the music therapy (BS) were unaware of participant allocation.

Ethical Approval

- Ethical clearance was obtained from the Institutional Ethics Committee College of Dental Sciences and Research Centre, Ahmedabad.
- Participants were included in the study only if their parents or caretakers signed a written consent that explained the benefits of the music therapy program by training them in playing the Tabla, which could subsequently enhance their oral health status, motor skills, and social skills.

- A "No Objection Certificate" was obtained from both the schools whose children participated in the study. This certificate ensured that the schools had no issue in letting the music therapist teach the children with autism.
- An open-ended registration for this study was made on Open Science Framework (https://doi.org/10.17605/OSF.IO/D5WPB).



METHODOLOGY – ASSESSMENT, SCORING AND DATA COLLECTION

Pre-intervention assessment

Diagnosis of autism was confirmed by the Childhood Autism Rating Scale (CARS) by the pediatric neurologist and a psychologist. The CARS score varies between 15-60. Below 29.5, a child is considered non-autistic, between 30-36.5 is scored as mild to moderately autistic, and between 37-60 is recorded as moderate to severely autistic. The CARS has an internal consistency reliability alpha coefficient of 0.94, an inter-rater reliability correlation coefficient of 0.71, and a test-retest correlation coefficient of 0.88 (Schopler et al., 1988).

Before the training sessions, the participants were assessed for oral health status, motor skills, and social skills. A pediatric dentist unaware of the group allocation evaluated the oral health status.

Gingival Index: Assessing the condition of the gingiva includes its quality and location at all four locations of the teeth (buccal, mesial, distal, lingual). The Gingival Index helps to understand the severity of the gingival inflammation (Loe, 1967).

Plaque Index: Oral Health can worsen if plaque accumulates and the periodontal condition weakens. The Plaque Index is thus used to assess the severity and location of soft debris aggregates on all four surfaces of the teeth (Silness and Loe., 1964).

Both these indices are recorded on six index teeth in each arch. In children, if any permanent index tooth is absent, its primary counterpart is used for scoring (Tandon S., 2018). The scores were recorded using a mouth mirror, dental explorer, and periodontal probe.

Calculation of the scores in each index follows the same steps. In each index, the scores of each tooth are added and divided by the total teeth examined. Based on this, the scores vary from 0 to 3. These scores are interpreted as Excellent (0), Good (0.1-0.9), Fair (1.0-1.9) and Poor (2.0-3.0).

Autism Social Skills Profile: This scale has three subscales that cover social reciprocity, social participation/avoidance, and detrimental social behavior. The scores are calculated by asking the caretaker a questionnaire whose answers are rated on a 4-point Likert scale (Bellini and Hopf., 2007). The caretakers of each participant answered all questions to a researcher (AP) who was blinded from group allocations.

Social Reciprocity: This subscale consisted of questions about the active maintenance of social interactions and the demonstration of perspective-taking skills.

Social Participation/Avoidance: This subscale comprised questions on social engagement or withdrawal from participation.

Detrimental Social Behaviour: This subscale included items representing socially inappropriate behaviors that could lead to directly negative peer interactions.

The internal consistency reliability score was high ($\alpha = 0.926$) and the test-retest reliability coefficient score was 0.904.

Quality of Upper Extremity Skills Test (QUEST): The upper limb movements indicate their functionality and are also a marker for typical development. The QUEST helps in describing the quality of movements and planning intervention programs. It assesses the performance of the upper limbs in various activities related to dissociative movements, grasp, weight-bearing, and protective extension. Based on this, the participants are scored out of a total score of 100. The test-retest reliability of QUEST ranges from 0.75 to 0.95 (DeMatteo et al., 1993). A physiotherapist and an occupational therapist carried out this test. Both these therapists were blinded from group allocations.

Music therapy – Teaching the Tabla to Children with Autism

Training duration

Participants in the experimental group were trained in self-playing a musical instrument for 3 months. Each training session lasted 1 hour and each participant was taught one-to-one for 10 minutes. The time frame for teaching a participant during each session varied depending on the child's attention span, mental state, and reciprocal behavior of each child. Based on the experience of the music therapist, it is important to note that this period varied in each autistic child.

Training regime

The training sessions were held in a closed room on the school premises. The participant and the music therapist sat on the floor facing each other. One pair of Tabla was placed in front of the participant while the other was placed in front of the music therapist. An electronic metronome (Sundamala Dx, Radel Electronics Pvt. Ltd.) was used to enhance the quality of teaching rhythmic patterns.

The music therapy treatment model proposed by Michael Thaut was executed in the training sessions. This treatment model divided the training sessions into three levels: Basic, Intermediate, and Complex (Thaut, 1984). Some variations existed at each level based on the participants' learning speed and their reactions to the instrument acoustics.

Basic Level

The beats played on the Tabla are based on how the fingers are positioned on the instrument. The initial beats were played by striking the palms on both drums. This striking was expected to be rhythmic. The basic level focused on letting the autistic child manually explore the musical instrument and let the musical instrument serve as a mutual point of contact for the therapist and the participant. Physical contact with the child is established right from the basic level. This can be done by guiding the child's hands to the drum area where the desired sound is produced (Figure 2). Further reinforcement of the taught beat can be done by asking the child to imitate the beat played by the therapist.

Intermediate Level

The next beats taught saw more use of individual fingers that had to be curled at times to produce the beat. These beats were also taught using the echo back technique where the participant was asked to play the same beat the therapist played. Each beat targeted the involvement of multiple muscles from the fingers to the shoulders. At this level, special focus is on body percussion activities and clapping patterns that keep the participants interested. The beats and claps are expected to match the electronic metronome. There should also be an emphasis on imitation exercises where the child tries to match the beats played by the therapist (Figure 2). This helps improve the child's attention and focus.

Complex Level

A combination of beats is taught to the children after they can satisfactorily play individual beats. This establishes right/left awareness among the participants. To make it more interesting for them and to help them memorize these beats, the children were often taught by associating the beats with numbers, letters, songs, or voices resembling the sound produced by the beats. These additional exercises helped in strengthening the rhythmic sense of the children. Children were also paired and made to play together to check their inter-playing coordination skills (Figure 2).

Figure 2 Rhythmic Music Therapy Training Regime

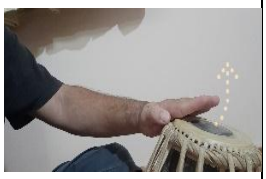
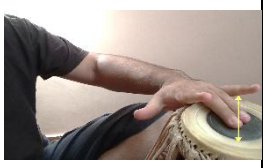
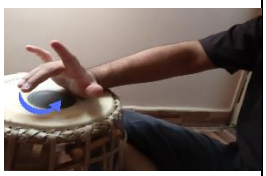
List of beats taught	How to play the beat	Drum	Muscles involved in toothbrushing						
			FPB	FCR	FPL	FDS	PT	BB	D
	Posture for playing tabla involves sitting cross-legged with a straight back. The elbows should never take the support of the thighs. It is important to note that a radial wrist deviation is always constant. *	Both					●		●
	DIN: This beat is played by adducting the fingers. Sound is produced when these fingers strike the black circle and immediately lift the palm when a resonated sound is produced. A variant of this beat, "TUN" is played by abducting the fingers.	RD	●		●		●		●
	TI: This beat involves adducting the middle & ring finger. Sound is produced when these two fingers hit the black circle. The final position should see the distal phalanges of these fingers grasp the instrument.	RD		●		●	●		●
	TE: This beat is often played in conjunction with "Ti." It follows the same rules for "Ti." However, it is played only with the index finger.	RD				●	●		●
	TAK: This beat involves curling the fingers with the thumb by giving it a concave shape. Sound is produced when these fingers grasp & adhere to the black circle tightly.	RD	●	●	●	●	●		●
	KE: This beat involves moving the palm in hyperextension, extension, neutral and flexion position solely with the wrist. Sound is produced when the palm and fingers hit the drum.	LD	●	●	●	●	●		●
	GHE: This beat involves curling the middle & ring finger from their extension to flexion. The resonance of the sound is produced by the power & precision of the distal phalanges of the two fingers.	LD		●		●	●		●
	GA: This beat is played in the same way as "Ghe." However, in this beat, only the index finger is used.	LD		●		●	●		●

Table 1 List of Beats Taught; LD=Left Drum, RD=Right Drum, FPB=Flexor Pollicis Brevis, FCR=Flexor Carpi Radialis, FPL=Flexor Pollicis Longus, FDS=Flexor Digitorum Superficialis, PT=Pronator Teres, BB=Biceps Brachii, D=Deltoid; * Radial Flexion of the wrists is also seen during toothbrushing; ● Indicates muscle used while playing the beat

Caretakers were educated on the importance of maintaining the oral health of children with autism. They were advised to use a soft-bristled toothbrush, a pea-sized amount of toothpaste, and the correct toothbrushing method.

Post-Intervention Assessment
After the training sessions participants were again assessed for oral health status, social skills, and motor skills.

Statistical Analysis
The statistical data was analyzed using the SPSS (version 23) software. This study had a control and an experimental group, with 12 participants in each group (n=24). Following the intervention, pre-test and post-test results were recorded and analyzed. A descriptive independent t-test and a paired t-test were done for intergroup and intragroup comparison respectively.

RESULTS

Oral Health Status

The participants' oral health was analyzed using the gingival and plaque indices. The gingival index suggests a non-significant change in the experimental group. However, the plaque index showed a significant change in the experimental group in the intragroup comparison ($p < 0.001$). In the experimental group, intergroup comparisons revealed a reduction in the mean gingival and plaque index values. However, these values were statistically not significant ($p > 0.05$) (Table 2 and Table 3).

Social Skills
Social skills evaluation included social reciprocation, participation, and detrimental social behavior scores. There was a statistically significant improvement in the social participation ($p < 0.009$) and social reciprocation ($p < 0.001$) scores in the experimental group in the intragroup comparisons. Social participation was also significantly improved in the experimental group in the intergroup comparisons ($p < 0.033$). Detrimental social behavior scores showed a decrease in the experimental group. However, these results were insignificant in the intergroup and intragroup comparisons (Table 2 and Table 3).

Motor Skills
Motor skills were primarily evaluated for the upper limbs. There is a statistically significant difference observed in both the intergroup and intragroup comparisons ($p < 0.005$) in the experimental group (Table 2 and Table 3).

Table 2 Intragroup comparisons done using paired t-test

Group	Parameter	Duration	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P value
Control	Gingival Index	Before	1.18	12	.06	.01623	.01667	0.427 NS
		After	1.16	12	.06	.01862		
Experimental	Gingival Index	Before	1.16	12	.06	.01746	.02500	0.100 NS
		After	1.14	12	.06	.01867		
Control	Plaque Index	Before	1.20	12	.09	.02527	.00167	0.953 NS
		After	1.20	12	.09	.02614		
Experimental	Plaque Index	Before	1.23	12	.09	.02551	.08333	0.001 *
		After	1.15	12	.05	.01553		

Group	Parameter	Duration	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P value
Control	Social Reciprocation	Before	47.083	12	5.8536	1.6898	.6667	0.452 NS
		After	46.417	12	5.2649	1.5199		
Experimental	Social Reciprocation	Before	46.333	12	8.4781	2.4474	-1.9167	0.001 *
		After	48.250	12	12.7288	3.6745		
Control	Social Participation	Before	23.33	12	5.2281	1.5092	-.5000	0.491 NS
		After	23.83	12	5.6057	1.6182		
Experimental	Social Participation	Before	23.75	12	7.0340	2.0305	-5.0000	0.009 *
		After	28.75	12	4.9383	1.4256		
Control	Detrimental Social Behaviour	Before	30.083	12	5.9614	1.7209	-.8333	0.376 NS
		After	30.917	12	4.5817	1.3226		
Experimental	Detrimental Social Behaviour	Before	30.167	12	6.0277	1.7401	.2500	0.475 NS
		After	29.917	12	4.9810	1.4379		
Control	Motor Skills	Before	76.75	12	10.1902	2.9417	-.5000	0.590 NS
		After	77.25	12	9.8177	2.8341		
Experimental	Motor skills	Before	80.42	12	14.3809	4.1514	-9.2500	0.005 *
		After	89.67	12	7.1774	2.0719		

Table 3 Intergroup comparisons done using descriptive independent t-test

Parameter	Duration	N	Control		Experimental		P value
			Mean	SD	Mean	SD	
Gingival Index	Before	12	1.178	.05622	1.1625	.06047	0.513 NS
	After	12	1.1617	.06450	1.1375	.06468	0.369 NS
Plaque Index	Before	12	1.20	0.09	1.23	0.09	0.452 NS
	After	12	1.20	0.09	1.15	0.05	0.089 NS
Social Reciprocation	Before	12	47.08	5.85	46.33	8.48	0.803 NS
	After	12	46.42	5.26	48.25	12.73	0.649 NS
Social Participation	Before	12	23.33	5.23	23.75	7.03	0.871 NS
	After	12	23.83	5.61	28.75	4.94	0.033*
Detrimental Social Behavior	Before	12	30.083	5.9614	30.167	6.0277	0.973 NS
	After	12	30.917	4.5817	29.917	4.9810	0.614 NS
Motor Skills	Before	12	76.75	10.19	80.42	14.38	0.479 NS
	After	12	77.25	9.82	89.67	7.18	0.002*

DISCUSSION

Poor oral health of children with autism can be attributed to several reasons. Autism spectrum disorders (ASD) is an inclusive term for a group of neurodevelopmental disorders sharing similar impairments in communication, reciprocal social interaction, and restricted, repetitive

behavior (Fournier et al., 2010). The National Institute of Child Health and Human Development has defined autism spectrum disorder as, "A complex biological disorder that generally lasts for a person's entire life, beginning before the age of three, in the developmental period, and causes delays or problems in many different ways in which a person develops or grows" (Ferrazzano et al., 2020).

An observation of "abnormal children" made by a Viennese pediatrician named Ronald in 1944 is said to be the first mention of Autism in India. The prevalence of ASD today is around 3 million in the Indian sub-continent (Sam et al., 2020; Juneja and Sairam, 2018). The range of symptoms exhibited by each individual diagnosed with autism can range from "highly skilled/functional" to "severely challenged/autistic." Autism typically appears during the first 3 years of life showing symptoms like stereotyped motor behavior, abnormal responses to sensations, absent or delayed speech or language, and abnormal ways of relating to people, objects, and events. Genetic, environmental, and neural factors affect each child differently irrespective of their age. the cognitive and behavioral characteristics of children with ASD show great heterogeneity, with the degree of deficit being unclear (Green et al., 1995). Participants included in this study were between 4 to 12 years of age.

Children with ASD are at a high risk of developing oral health conditions like dental caries and compromised gingival and periodontal hygiene. Higher levels of anxiety, heightened response to stimuli, poor cooperation, and low dental attendance, are highlighting factors of poor oral health in children with autism compared to neurotypical children (Liu et al., 2019). This can be attributed to the improper fine motor skills in children with autism, who have poor upper limb coordination and insufficient manual dexterity required for performing tooth brushing and flossing (Luppanapornlarp et al., 2010; Bartolome-Villar et al., 2016; Ferrazzano et al., 2020).

There is enough evidence of music therapy's benefits on individuals with autism based on the preference, responsivity, and predisposition of this group to music stimuli. Musical perception in individuals with autism is characterized by superior identification and labeling of pitch, and enhanced sensitivity for pitch direction and contours (Simpson and Keen, 2011). Whipple reported that music was effective as an intervention with individuals with autism irrespective of the age of participants, type of intervention, treatment, methodology, and profession of the music provider (Whipple, 2004).

Carol Goldstein first reported using a percussion instrument as one of the many interventions done on an 8-year-old autistic girl. According to Goldstein, the idea was to add "color to the sound and provide the child with a constructive outlet for her aggression" (Goldstein, 1964). Another percussion instrument called bongo, has also been used as a musical bridge that could tap out communication, messages, and emotions in children with autism (Warwick, 1984).

The musical instrument used in our study was the Tabla, another percussion instrument. Sound production in this instrument is entirely by the way the fingers hit the drums. Fine motor skills can be refined through playing such rhythmic instruments which can further refine and appropriately time finger, hand, and arm movements (Srinivasan and Bhat, 2013). Toothbrushing involves the sequential utilization of muscles of the hand which can help in effective mechanical plaque control. This study targeted the upper limb muscles' fine and gross motor skills through training in a percussion musical instrument like the Tabla.

Flexor pollicis brevis, flexor pollicis longus, flexor carpi radialis, pronator teres, biceps brachii and deltoid are the commonly utilized muscles while using a toothbrush (Uenoyama and Inada, 1990). Computer software analyzed the action of various muscles when subjects resorted to bass, modified Stillman, scrubbing, and rolling techniques. The most important muscles that generate action potential during toothbrushing are flexor carpi radialis, flexor pollicis longus, biceps brachii, and thumb flexor (Endo et al., 2003). In 1995, Kono and Inada compared the grip strength in school children and adults. The range of motion of the upper limbs and the muscles involved were closely studied. They concluded that the grip pressure relies entirely on the thumb and index finger. Muscles like flexor digitorum brevis, root flexor, pronator biceps, and deltoid muscles along with flexion of the metacarpophalangeal joint of the second finger are most commonly used during toothbrushing. The most important motions during toothbrushing are the flexions of the wrist, radius, ulna, and elbow joints (Kono and Inada, 1995). These motions were utilized while playing the beats on the Tabla during the music therapy sessions (Table 1).

In this study, motor and social skills are physiological, psychological, or neurological responses to music. They are connected with an analogous non-musical response in the form of oral health. There is growing evidence that music therapy can enhance the motor and social skills of children with autism (Boso et al., 2007; Zarafshan et al., 2017; Weitlauf et al., 2017; Damm and Workman, 2017). Hence, the objective of this study was to enhance the oral health of children with autism by improving their mechanical plaque control skills, which required apt motor and social skills. However, training the children to play the instrument should be structured and meticulous to achieve the needed results.

At the end of the training sessions, the experimental group improved in all three domains – motor skills, social skills, and oral health status.

ASD, Music & Oral Health Status

According to Ferrazzano et al, children with ASD may have a major risk of developing caries, periodontal lesions, and alteration of the oral microbiome. The authors add that because of their hyperactivity and their stereotypical and self-injurious attitudes, these children have a greater probability of having oral trauma. If not eliminated, all these diseases can be reduced by personalized preventive approaches and a correct personalized educational model for ASD patients (Ferrazzano et al., 2020). To our knowledge, no previous study has aimed to see the effect of a musical therapy intervention on the oral health of children with autism.

The intragroup results of our study show that following the intervention, the experimental group showed a significant reduction in the plaque index score (Table 2). There was also a reduction in the mean scores of both gingival and plaque indices in the intergroup comparisons (Table 3). However, these results were not statistically significant. The reason for this can be attributed to many reasons. Firstly, the reduction in plaque index score can be due to the improved motor skills of the participants at the end of the training duration. However, this cannot be the sole reason influencing the results of oral health status. Even if the participants had enhanced motor skills, it is still noteworthy that they took longer to adapt to their new skills (Matson et al., 1990). Children with autism display oral sensitivity and often show behavioral tantrums during toothbrushing (Du et al., 2018; Smith and Belcher, 1985; Popple et al., 2016; Subramanium and Gupta, 2011). Moreover, because of their low cognitive functioning, they need to be instructed repeatedly (Pilebro and Backman, 2005).

Three more factors that can influence the periodontal condition of children with autism are their irregular dietary habits, ongoing medications, and the tools they use for plaque control (electric or manual) (Shapira et al., 1989; Ferrazzano et al., 2020). These are vital because salivary pH and buffering capacity are lower in autistic children. Moreover, microbiological studies have revealed an increased prevalence of Hemophilus in saliva and Streptococcus in saliva in patients with autism. Thus, these periodontal factors, which are difficult to control outside the experimental environment can assert their effects on the outcome of this study.

ASD, Music & Motor Skills

In the present study, the Quality of Upper Extremity Skills Test (QUEST) was used to evaluate the motor skills of children with autism. The experimental group showed a significant improvement in motor skills in intergroup and intragroup comparisons (Table 2 and Table 3). The findings of this study agree with the findings of two other studies where the researchers evaluated the effect of musical instrument playing on children with Down's Syndrome. Down's Syndrome also causes developmental delays in motor skills due to chromosomal abnormalities. In the first study, the effect of 1 month of Tabla training was observed on the motor skills of children between 6 to 12 years of age with Down's Syndrome. This study showed a significant change in the hand functioning of the children after the intervention (Maqbool and Rajaguru, 2015). The second study evaluated how self-playing the drums improved their motor development. After 6 months of training, the participants showed a significant improvement in the motor development of children with Down's Syndrome (Taufiq et al., 2018).

The involvement of the hand-motor component in Tabla's playing served two functions apart from promoting motor activity and capturing the child's interest in the therapy. Firstly, the simultaneous engagement of several sensorimotor systems while playing the instrument has the potential to strengthen the connections between auditory and motor regions. Secondly, the act of music making itself has the potential to facilitate social communication and interaction in children with autism because it exploits their strong interest in music as well as their positive response to it (Wan and Schlaug, 2010). Since sound production in Tabla happens through the fingers hitting the drums, it is safe to assume that the deep pressure technique (firm touch pressure providing calming input) is also delivered through it. Moreover, instrument exploration and the feeling of vibrations of the sound produced by the instrument can also help in sensory stimulation (Baranek, 2002). A PET scan of a neurological study showed that finger tapping activated those areas of the brain responsible for motor skills, social skills, and music perception (Aoki et al., 2009).

ASD, Music & Social Skills

Improper social functioning is the defining feature of autism. Social participation, reciprocation, and social behavior in a given setting reflect a child's cognitive development. Social, behavioral, and cultural factors like poor family stability, lack of parents' knowledge of oral health, low family income, and improper eating habits, have been associated with increased caries prevalence in children with autism (Ferrazzano et al., 2016).

Impaired motor development can derail the development of social communication. This is because timed gestures and gaze-following are the building blocks of joint attention (Chukoskie et al., 2013). Furthermore, playing drums (another percussion instrument) increased the social skills of children with autism in areas concerned with cooperation, self-control, and imitation (Yoo and Kim, 2018). Hans Asperger (discoverer of Asperger

syndrome) believed that it was impossible to tease motor clumsiness from a lack of social understanding and that the two deficits were linked.

Social skills were evaluated using the Autism Social Skills Profile which considered social reciprocation, participation, and detrimental social behavior. Social reciprocation improved significantly in the experimental group in the intragroup comparisons (Table 2). Social participation showed a significant enhancement in both intergroup and intragroup comparisons. Detrimental social behavior decreased in the experimental group but was not statistically significant (Table 2 and Table 3).

The results of social skills in this study agree with that of Lagasse in 2014 who showed a significant improvement in social skills of 17 children with autism between the ages of 6 to 9 years who were given music therapy group intervention. The same study also demonstrated initial support for using music therapy in social groups to develop joint (LaGasse, 2014). The enhancement in social participation and reciprocation agrees with the findings of a systematic review that showed the effect of music therapy on improving social outcomes (communication, participation, joint attention, frequency of responses) in children and adults with ASD (Boster et al., 2021). Our study was conducted for 12 weeks and showed an enhancement in social participation and social reciprocation skills. This change is certainly possible as confirmed by a neurological study that showed improved social communication and brain connectivity following a music therapy intervention for 8-12 weeks in children with autism between the ages of 6-12 years (Sharda et al., 2018).

Limitations

This study has shown that oral health status, social skills, and motor skills improved in the experimental group following a music therapy intervention. However, factors like dietary habits, mode of plaque control, ongoing medications, and behavior during toothbrushing sessions were not monitored. Even though these factors can affect the oral health outcomes of the study, the effect of music therapy in enhancing social and motor skills cannot be denied.

The Quality of Upper Extremity Skills Test (QUEST) was used to evaluate the motor skills in our study. This test was primarily developed for children with cerebral palsy between 18 months to 8 years of age. However, based on the recommendations of the International Handbook of Autism and Pervasive Developmental Disorders, the QUEST can be used for children with autism (Hilton, 2011). Moreover, the QUEST specifically focuses on the motor skills assessment of upper limbs which is appropriate for the current study. The results of motor skills obtained through QUEST in this study show the potential of Tabla as a musical instrument for improving motor skills in children with developmental disabilities.

CONCLUSION

Music Therapy is one of those approaches that directly affects the neural networking of the brain of children with Autism. The present study lays down the foundation of a possible link between rhythm-based music, pediatric dentistry, and autism. This intervention is more desirable in individuals with ASD as it has a neurological effect in areas of the brain concerned with motor and social skills. Within the limitations of this study, the following conclusions can be drawn:

- Poor upper limb coordination is a major factor for detrimental oral health in children with autism.
- Oral health status improved following the music therapy intervention.

- Motor skills and social skills scores increased after music therapy sessions. An interplay between these variables affects the oral health of children with autism.
- A correlation between the muscles used during toothbrushing and playing the Tabla can be appreciated.

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Conflict of Interest

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